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An update on the jellyfish swarming dynamics along the southern coast of Kerala

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Original Article

Abstract

A comprehensive survey on jellyfish diversity and distribution, conducted along the coastline from 2017 to 2021, documented 12 scyphozoan species, in addition to one species each from Cubozoa and Hydrozoa. Collections were mostly from the fishing gears, beach seine and ring seine. Frequent jellyfish species observed included *Acromitus flagellatus*, *Crambionella* spp., *Chrysaora* spp., *Netrosoma* sp., and *Cyanea* spp., with *Cephea*, *Thysanostoma*, and *Rhopilema* being rarely encountered. The study highlighted notable seasonal swarming patterns, particularly with *Crambionella* sp. in the post-monsoon months (October and November), showed an average count of 200-800 individuals per net, while swarms of *Chrysaora* spp. could reach into the thousands per haul. The swarming season typically begins with *Netrosoma* sp. (blue jelly) in July-August, followed by *Chrysaora* spp. and *Crambionella* sp., continuing until December-January. Environmental factors like the depletion of predator species due to overfishing, climate warming, and the construction of marine structures are likely contributing to the increased jellyfish population. These blooms play a significant role in the coastal ecosystem, where some jellyfish species act as filter feeders and others as predators, impacting local food webs. For fishers, large jellyfish blooms are a challenge, often leading to heavy loads during beach seine operations. Addressing the environmental drivers behind jellyfish blooms through a comprehensive management approach could help mitigate their impact on both ecosystems and fisheries.

Keywords: *Jellyfish diversity, Swarming dynamics, Scyphozoans, coastal ecosystems, Blooms*

Introduction

Jellyfish represent among the oldest living animals, and the fossil remains indicate that they have been on Earth for more than 700 million years. True jellyfish, belonging to the free-swimming medusa phase of the class Scyphozoa (Phylum: Cnidaria), play a significant role in the marine ecosystem's food web (Hays *et al*., 2018). Globally, over 200 species of Scyphozoa have been documented, with habitats ranging from the deep sea to shallow coastal waters (Daly *et al*., 2007). These jellyfish are widely distributed across the world's oceans and primarily feed on smaller organisms such as phytoplankton, zooplankton, copepods, and ichthyoplankton, making them important predators in the marine food chain (Thomas *et al*., 2020). Jellyfish, particularly members of the classes Scyphozoa, Cubozoa, and Hydrozoa, are widely distributed in the marine ecosystems along the Indian coastline. Historically, jellyfish blooms have been a regular phenomenon, affecting both the coastal ecosystem and fisheries. However, systematic studies on jellyfish distribution in India only began in recent decades, with earlier accounts primarily limited to sporadic sightings or subjective observations by fishers and researchers. The global diversity of jellyfish is not well understood and is often underestimated, primarily due to the complexities and confusion surrounding their taxonomy. Misidentification, similarities in morphological traits, and the lack of comprehensive studies on many jellyfish species contribute to this uncertainty (Kumawat *et al*., 2022). Jellyfish distribution and taxonomy along the Indian coastline have been an area of growing scientific interest, especially with the rising frequency of jellyfish blooms impacting fisheries and marine ecosystems. The study of jellyfish diversity in

India dates back to early works by researchers such as Vanhoffen (1888) and Menon (1930, 1936), who documented the presence and characteristics of various jellyfish species in Indian waters. Thirty-four species of schyphozoans can be reported from Indian waters (Chakrapany, 1984). Historically, there have been limited reports on jellyfish from the Indian region. However, recent years have seen a growing interest and an increase in such reports (Baliarsingh, 2020; Behera *et al.*, 2020; Karunarathne and de Croos, 2020; Mondal and Devi, 2020).

Jellyfish swarms have been documented in the oceans since ancient times. However, recent studies indicate that their numbers have increased significantly, posing challenges to fisheries and tourism. These swarms often occur in response to anthropogenic disturbances or shifts in oceanic conditions. Many researchers suggest that global warming is a key factor driving the rise in jellyfish populations, as it can influence their distribution, growth, and larval production (Richardson *et al.*, 2009; Lee *et al.*, 2013). Changes in global climate and local ecosystems, along with historical patterns of jellyfish abundance, may result in the proliferation of certain species in specific areas. In Indian waters, global warming, combined with the decline of predatory fish species and turtles due to overfishing, may further contribute to jellyfish population growth (Williams, 2015). Additionally, jellyfish appear to benefit from eutrophication, which leads to increased small zooplankton populations, higher turbidity, and hypoxic conditions-factors that often favour jellyfish over fish (Purcell *et al.*, 2007). Fishing activities also reduce predator populations, triggering ecosystem shifts that support jellyfish proliferation. The resulting fluctuations in jellyfish biomass can negatively impact fishery resources and disrupt marine ecosystems. Scyphozoan jellyfish, in particular, have a significant influence on coastal ecosystems as they feed on the larvae and juveniles of important pelagic fish species, further affecting marine biodiversity and fisheries. Along the southern coast of Kerala, traditional fishers operating gillnets and boat seines are encountering significant challenges during the post-monsoon period, primarily due to the mass swarming of jellyfish. These swarms not only disrupt fishing activities but also cause economic losses, as the jellyfish often damage fishing gear and reduce the availability of target species. The increased population explosion can be due to the lack of complex physical features, which makes these organisms extremely adaptable to any change in their habitat environment. Eutrophication, climate change, overfishing, alien invasions, and habitat modifications were all possible important contributory factors of jellyfish swarms (Duarte *et al.*, 2013; Richardson and Gibbons, 2008). Jellyfish swarms have damaged the normal composition and function of marine ecosystems and ecological environments (Qu *et al.*, 2016). Kumawat *et al.* (2021) have reported the large-scale swarming of Scyphomedusae in the Indian Ocean, particularly in the northeastern Arabian Sea, and have disrupted fishing activities. Despite their ecological significance, the diversity of these jellyfish remains inadequately understood.

In India, Jellyfish fishing is in the developmental phase. Of the 35 species of jellyfish identified in Indian waters, only four species are actively harvested along the coasts of Kerala, Gujarat, and Andhra Pradesh for export (Saravanan, 2018). Hence, to conduct a detailed study on the diversity and distribution of jellyfish along the southern coast of Kerala, it is crucial to identify the potential species for fishing as well as their ecological importance. This region, which experiences significant jellyfish blooms, could benefit from an inventory of species that would not only aid in understanding their ecological impact on local fisheries but also contribute to broader research on jellyfish dynamics in Indian waters. A study was initiated in ICAR-Central Marine Fisheries Research Institute (ICAR-CMFRI) during 2017 on scyphozoan and cubozoan jellyfish diversity, abundance, and swarming dynamics, and the results of the present investigation are presented in this account.

Material and methods

Regular sampling has been carried out for three years since 2017 along the Thiruvananthapuram coast. Focal points for regular observation were selected based on the field survey together with information gathered from local fishers (Fig. 1). Sampling was carried out from beaching shoals and landings from major gears as shore seine, ring seine, and gill nets. Vessel-based collections were carried out in the Kappil backwaters. The freshly collected jellyfish were brought to the laboratory to record their morphological characters and preserved in 10% formalin for further analysis.

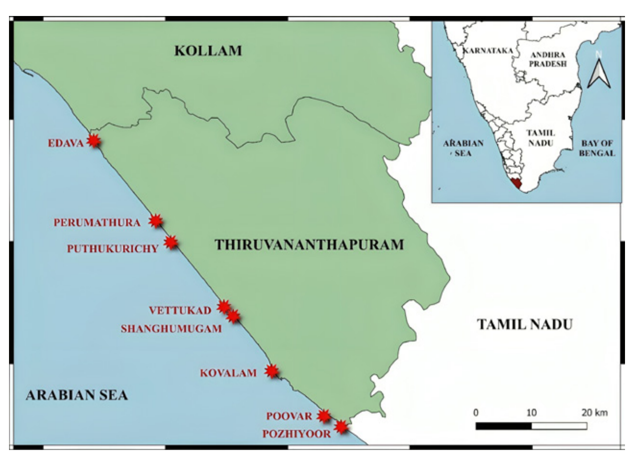

Fig. 1. Sampling sites of the study

Results and discussion

Species diversity

The class Schyphozoa consists of 4 orders (Stauromedusae, Coronatae, Semaeostomea, Rhizostomeae), 20 families, 66 genera and about 200 species. The present investigation on jellyfish diversity and distribution has recorded 10 species of scyphozoans belonging to 7 families and one each in class Cubozoa and Hydrozoa, though earlier works by Nair (1946). Riyas (2013) reported 19 species from this coast in his M.Phil. work. Collections were mostly from different fishing gears, dominant being beach seine and ring seine. The majority of the recorded specimens belong to the class Scyphozoa, *viz., Acromitus flagellatus, Crambionella orsini, Chrysaora* spp. (4 different morphological types), *Marivagia stellata, Cyanea* spp.*, Cephea coerulea, Netrostoma coerulescens*s *Thysanostoma* sp.*, Lobonemoides* sp., and *Rhopilema hispidum.* The list also includes one Cubozoa collected from trammel nets, off Perumathura and the species identified as *Chridropoides* sp. Hydrozoan jellyfish, especially *Aequorea* spp., were also recorded in the present study.

Chrysaora sp. appears to exhibit characteristics indicative of aggregation and blooming. However, the systematic classification and taxonomy of several species within this genus have remained a subject of substantial ambiguity, as different authors have offered varying interpretations concerning their morphological traits. In the efforts to identify species within the *Chrysaora* genus, we adopted a methodology centred on the utilisation of morphological characteristics, supplemented by the application of available identification keys, as proposed by Morandini *et al.* (2010). Consequently, we provisionally assigned these species as *Chrysaora caliparea, Chrysaora melanaster,* and *Chrysaora chinensis*. It is imperative to underscore our firm conviction that, except *C. melanaster*, all other species may potentially constitute morphotypes of the same species. This assertion is grounded primarily in the substantial variations observed in terms of colouration and pigmentation within the umbrella region among the specimens studied, thereby prompting the proposition that they collectively constitute a species complex. Notably, the presence or absence of pigmentation stands out as a distinctive character, and variances in colour patterns are recurrent among the recorded specimens. It is also pertinent to highlight that earlier investigators have alluded to *Chrysaora* as a developmental stage of *Dactylometra,* characterised by the presence of 24 tentacles, as documented by Menon (1930).

The genus *Cyanea* also presents a conundrum about species confirmation, and it is noteworthy that tentacles tend to be clustered in this genus. Among the four different specimens collected within the *Cyanea* genus, *Cyanea* sp. 1 displayed comparatively smaller arms and formed swarms during August through October. Species 2, characterised by very thin, long arms and a body width of 95-100 cm, was recorded only once. Local fishermen suggested that this species is common in deeper waters and is locally known as "Aanachori," likely due to its substantial size. The other two types within this genus are typically white in colour, one featuring a plain umbrella and the other adorned with brown dots.

Larson (1990) has previously commented on the challenges associated with identifying North Pacific species of *Chrysaora,* noting that misidentifications are often due to the substantial variation within the same species and the similarities in colour patterns between different species. The extensive variability observed within species is particularly conspicuous in the *Chrysaora* and *Cyanea* genera. The tentative identification of species, primarily based on morphological characteristics, should ideally be corroborated through DNA analysis. Notably, our study revealed four species that were observed during swarming, each displaying minute morphological differences in *Chrysaora*, while in *Cyanea,* three distinct specimen types with nearly identical features were noted.

The most frequently encountered species in our study included *Crambionella orsinii, Chrysaora* spp., *Netrosoma coerulescens*, and *Cyanea* spp. Besides, Galil *et al.* (2013) documented the presence of the jellyfish *Marivagia stellata* for the first time along the Kerala coast, specifically from Vizhinjam, Thiruvananthapuram. The estuarine species *Acromitus flagellatus*, characterised by micromouths, exhibited variations in chromatophore patterns on its umbrella. Many of the medusae we collected displayed beautiful spots and patterns on their exumbrellae. It is worth noting that young forms sometimes exhibited well-developed pigment spots, while mature forms often lacked these spots, indicating that their appearance may depend on the environmental conditions in which they reside. The list of jellyfish recorded from the southern coast of Kerala during the study and their abundance status is given in the Table. 1. The photographs of jellyfish collected from the coast are given in Fig. 2.

Swarming

The jellyfish population along the Kerala coast has become increasingly abundant, posing significant threats to marine species and creating major challenges for fishing operations. Jellyfish swarming along the coast and in adjacent backwater areas is a common occurrence, particularly during the post-monsoon months. During this period, jellyfish swarming typically ranges between 200 and 800 individuals per net, with peak numbers observed in October and November,

Table 1. List of jellyfish recorded from the southern coast of Kerala during this study

Class/ Order		Family	Species	Abundance
Scyphozoa/ Rhizostomeae		Catostylidae Gegenbaur, 1857	*Acromitus flagellatus* (Haeckel)	A
		Cepheidae; L. Agassiz, 1862	*Cephea* spp.	R
		Cepheidae; L. Agassiz, 1862	*Netrostoma coerulescens* Maas, 1903	A
		Cyaneidae; L. Agassiz, 1862	*Cyanea* spp.	C
		Cepheidae; L. Agassiz, 1862	*Marivagia stellata* Galil & Gershwin, 2010	C
		Pelagiidae Gegenbaur, 1856	*Chrysaora* spp.	A
		Lychnorhizidae Haeckel, 1880	Lychnorhiza malayensis	C
		Lobonematidae Stiasny, 1921	*Lobonemoides robustus*	R
		Catostylidae Gegenbaur, 1857	*Crambionella orsini* (Vanhoffen)	A
		Catostylidae Gegenbaur, 1857	*Crambionella* sp.	R
		Rhizostomatidae Cuvier, 1799	Rhopilema hispidum	R
		Thysanostomatidae Gegenbaur, 1857	*Thysanostoma* sp.	R
Cubozoa	Chirodropida	Chiropsalmidae Thiel, 1936	*Chiropsoides* sp. (van der Horst, 1907)	R
Hydrozoa	Leptothecata	Aequoreidae Eschscholtz, 1829	*Aequorea* spp.	C

*A-Abundant, C-Common, R- Rare

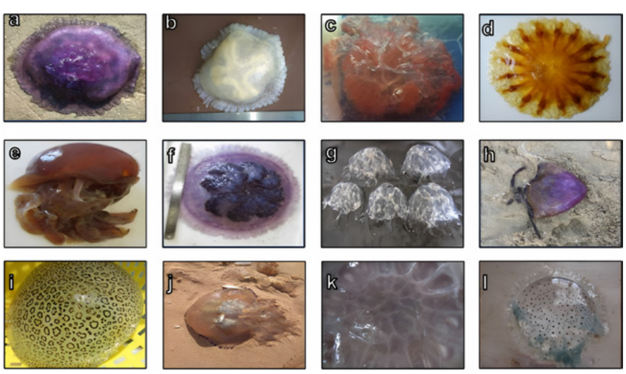

Fig. 2. Jellyfish species landed during the study period (a) *Netrostoma* sp., (b) *Crambionella* sp., (c) *Cephea* sp., (d) *Chrysaora* sp., (e) *Crambionella orsini,* (f) *Marivagia stellata,* (g) *Chridropoides* sp., (h) *Thysanostoma* sp., (i) *Acromitus flagellatus,* (j) *Lychnorhiza* sp., (k) *Cyanea* sp. and (l) *Rhopilema hispidum*

especially for *Crambionella orsini*. In the case of the *Chrysaora* species, the numbers can soar into the thousands per haul. The swarming of blue jellyfish, *Netrosoma coerulescens*, often marks the beginning of the season in July-August, followed by *Chrysaora* spp. and *Crambionella orsini*, with the swarming continuing until December or January. Swarming dynamics of various jellyfish along the southern coast of Kerala are shown in Fig. 3.

Beach seine operations, a common fishing practice along the southern coast of Kerala, often result in large catches of jellyfish, creating a problematic situation for local fishers.

Fig. 3. Jellyfish landings during shore seine operation at different fish landing centres along the southern coast of Kerala. Adimalathura (a, b, c and d), Kovalam (e, f and g), Poovar (h, I, j and k) and Poonthura (l)

Crambionella orsini is the most commonly encountered species in shore seine operations along the southern centres, while its occurrence is relatively low in other regions. In 2018, two species from the genus *Cyanea* (Scyphomedusae) were observed in high abundances between September and November, although their presence significantly decreased in 2019. That year, a swarm of *Lychnorhiza malayensis* and *Chrysaora* spp. was recorded along the coast. *Netrosoma coerulescens* was regularly observed during August and September, maintaining a consistent pattern of swarming. In 2018, the cubozoid jellyfish *Chiropsoides* sp. was found in disco nets operated from Thazhampally during the monsoon season. In fishing gears other than shore seines, detailed data on jellyfish abundance is difficult to collect, as fishermen typically discard jellyfish back into the fishing grounds, complicating accurate assessments of their population levels.

Jellyfish blooms have increasingly disrupted fishing operations, leading to the loss of many fishing days, particularly in shore-seine fishing, where large jellyfish hinder the manual labour required to drag the nets. This issue also extends to gill nets and ring seines, with fishers often suspending their activities due to the overwhelming presence of jellyfish, resulting in a significant reduction in fishing days and considerable economic losses for the fishing community. A notable observation is the sheltering behaviour of anchovies, silver bellies, and juveniles of clupeids and mackerel beneath the umbrella of jellyfish, particularly among the filamentous mouth and arms of medusa species. While this interaction may provide temporary refuge for these fish, jellyfish swarms harm fisheries. It reduces fish catch, delays fishing activities, lowers the market value of the catch, and damages fishing gear. Jellyfish slime also clogs nets and coats fish, which makes the catch less appealing to consumers, further reducing the economic value for fish vendors. In shore-seine operations, the entrapment of larger jellyfish exacerbates the problem, as it hampers manual net retrieval. Consequently, many coastal fishers are forced to suspend operations, further reducing the number of fishing days and intensifying financial losses. The adaptability and rapid reproductive rates of jellyfish exacerbate their nuisance, creating long-term challenges for local fisheries and causing significant disruptions to the livelihoods of fishing communities. The distribution of major seasons of jellyfish swarming in different gears is given in Table 2.

A. flagellatus is a common jellyfish species found in the estuaries and brackish waters of Kerala, as documented by Nair (1946, 1951) and Riyas (2013). This species often forms swarms in the Kappil backwaters during the post-monsoon period, typically from December to April. However, the drop in salinity and temperature during the monsoon months drives these jellyfish away from the backwaters. Interestingly, both small and large specimens have been observed together, suggesting the presence of a polyp stage in the same habitat. One unique characteristic of *A. flagellatus* is the variety of chromatophore patterns found in individuals collected from Kappil backwaters, though these patterns tend to fade when preserved or left without water for 24 hours. This species has also been recorded in nearby coastal areas, with Jones (1960) noting an association between *A. flagellatus* and the yellow stripe carangid fish, *Seleroides leptolepis*. The biochemical properties of *A. flagellatus* have attracted significant research attention. Studies have shown that collagen extracted from this species exhibits cell adhesion and antioxidant properties (Ranasinghe *et al.*, 2022). Besides this, research by Arulvasu *et al.* (2014) highlighted the anticancer effects of nematocyst venom from *A. flagellatus* on human breast cancer cell lines, demonstrating its potential in biomedical applications. Different chromatophore patterns observed in *A. flagellatus* and its collection are shown in Fig. 4.

Table 2. Distribution of major months of jellyfish entangled in different gears

Species	Months	Gear
Cyanea sp.	August- November	Shore seine, gill net
Netrostoma coerulescens	July- September	Shore seine, boat seine, gill net
Chrysaora spp.	August- October	Shore seine, gillnet, ring seine
Crambionella orsinii	October- November	Shore seine,
Chiropsoides sp.	June- September	Disconet

After understanding the perceptions and the menace posed by jellyfish to fishers during fishing activities, ICAR-CMFRI has taken proactive steps to mitigate the challenges while raising awareness about the ecological importance of jellyfish. Many fishers reported disruptions in their operations due to jellyfish swarms, which not only damage nets but also lead to injuries through stings. Stings from species like *Chrysaora* sp. and *Netrosoma* sp. have resulted in numerous cases of injuries, with severe reactions requiring medical attention, and in rare cases, fatalities have been reported. There has been increased awareness about the risks associated with jellyfish stings, including symptoms such as itching and swelling, and the need for appropriate safety measures to protect fishers from such encounters. In response, ICAR-

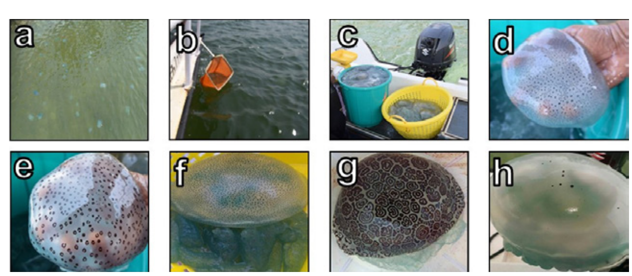

Fig. 4. (a) Swarming of *A. flagellatus,* (b, c) Jellyfish collection, (d, e, f, g and h) Different chromatophore patterns observed during the study

Fig. 5. (a) Exhibition of upside-down jellyfish in Sagarika Marine Research Aquarium, Vizhinjam, (b, c and d) Jelly-safe kit distribution

CMFRI initiated the distribution of "jelly safe kits" to fishers to ensure immediate first-aid treatment for jellyfish stings, helping to protect their health and reduce the operational risks. Also, ICAR-CMFRI has highlighted the value of jellyfish in the ecosystem through educational efforts, including the exhibition of jellyfish species in research aquariums and public programs. These initiatives aim to shift the perception of jellyfish from being purely a nuisance to an important component of marine ecosystems. By showcasing their ecological roles, such as their contribution to nutrient cycling and serving as food for other marine species, ICAR-CMFRI fosters a more balanced understanding of jellyfish and encourages sustainable fishing practices that accommodate the natural dynamics of jellyfish swarms. The distribution of jelly-safe kits to fishers and the exhibition of jellyfish in the research aquarium are shown in Fig. 5.

Conclusion

The study highlights that jellyfish blooms are a recurring and ecologically significant phenomenon along the southern Kerala coast, with notable economic implications for fisheries. Frequent swarming of species such as *Crambionella orsini*, *Chrysaora* spp., and *Netrosoma* sp. disrupts fishing operations and affects coastal livelihoods. The findings emphasise the need for baseline data on species composition and swarming patterns to support long-term monitoring. Factors like climate change, overfishing, pollution, and artificial coastal structures likely drive jellyfish proliferation. Addressing this growing concern requires a holistic approach that integrates ecological understanding with fisheries management and socio-economic considerations.

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Author contributions

Conceptualisation: SS, JS; Methodology: SS, JS; Data Collection: RS, SKK, AIKA; Data Analysis: SS, HJK, DDY; Writing Original Draft: SS; Writing Review and Editing: JS, HJK, DDY; Supervision: SB.

Data availability

The data are available and can be requested from the corresponding author.

Conflict of interest

The authors declare that they have no conflict of financial or non-financial interests that could have influenced the outcome or interpretation of the results.

Ethical statement

No ethical approval is required as the study does not include activities that require ethical approval or involve protected organisms/human subjects/collection of samples/protected environments.

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